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ANN based Multi-class Classifier for Epileptic cases

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ABSTRACT
ElectroEncephaloGraph (EEG) is a signal record of electrical activity of brain neurons. In this paper classification is done on normal and epileptic subjectby using multi-class classifier. The epileptic subjects are further sub-classified as hippocampal, epileptogenic and subjects having seizures. The multi-class classification into five classes was obtained with an accuracy of 88.4%.
KEY WORDS: ElectroEncephaloGraph, Multi-layer perceptron, Epilepsy, Hippocampal, Epileptogenic.

INTRODUCTION

The brain consists of a large number of highly connected elements called neurons (or nerve cell). These neurons have three principle components: the dendrites, the cell body and the axon. The dendrites carry electrical signals into the cell body. The cell body effectively sums and threshold these incoming signals. The axon is a single long fiber that carries the signal from the cell body out to other neurons. The point of contact between an axon of one cell and a dendrite of another cell is called a synapse. Figure 1 is a diagram of two biological neurons.

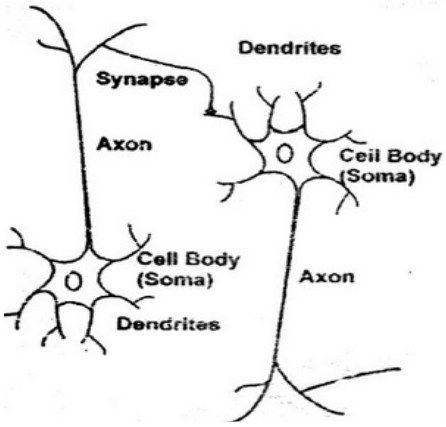

Figure 1: Schematic diagram of biological neurons

Epilepsy is a brain disorder that causes people to have recurring seizures. A seizure isusually defined as a sudden alteration of behavior due to a temporary change in theelectrical functioning of the brain, in particular the outside rim of the brain called thecortex. The hippocampal formationis a curved cortical structure in the medial temporal lobe of the brain. There is no consensus over which brain regions are encompassed by the term, with some authors defining it as the dentate gyrus, the hippocampus proper and the subiculum,and some closely related cortical areas in the parahippocampalgyrus, including the subicular complex (which itself is divided into the subiculum, presubiculum and parasubiculum) and the entorhinal cortex, are together referred to as the hippocampal formation. The hippocampal formation is thought to play a role in memory, spatial navigation and control of attention.The epileptogenic zoneis an area of cortex that is necessary and sufficient for initiating seizures and whose removal (or disconnection) is necessary for complete abolition of seizures. ElectroEncephaloGraph (EEG) maintains the electrical activity of brain. There are several methods that employ EEG to detect epilepsy [1][2][3][4].EEG features extracted are variance, power spectral density, entropy and energy. ANN based two-class classification is employed in previous work. In normal and epileptic subjects shows an accuracy of 99.2%, eyes open and eyes closed shows an accuracy of 100%, seizure and non-seizure shows an accuracy of 98.7% and hippocampal and epileptogenic shows an accuracy of 100% [5] [6]. The task at hand is to develop a multi-class classifier that may place the signal is one of the five classes, i.e. normal eyes open, normal eyes closed, hippocampal, epileptogenic and seizure subjects in one go.

APPLIED METHODOLOGY

A typical multilayer perceptron (MLP) network consists of a set of source nodes forming the input layer, one or more hidden layers of computation nodes, and an output layer of nodes [7] as shown in figure 2.

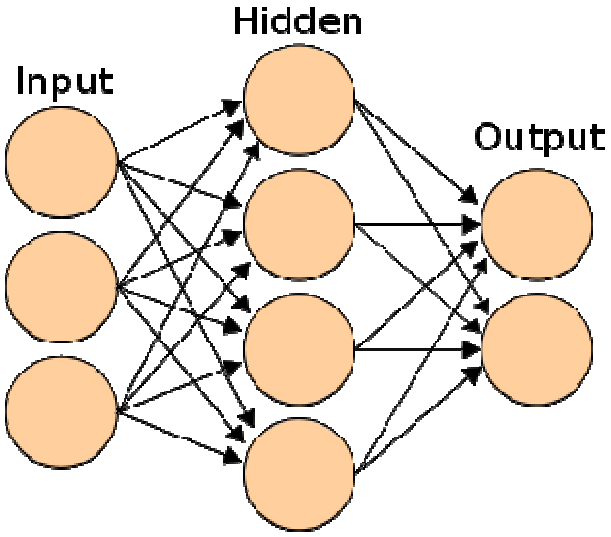

Figure 2: Multi-layer perceptron network

The MLP is composed of many parallel simple processing elements, called units and is categorized as a massively distributed processor. MLP has a natural tendency for storing and utilizing experiential knowledge. To get a specified or desired output, the MLP function learns from a set of predefined examples.

Our work involves classification of data obtained from Department of Epileptology University of Bonn [8]. This EEG data consists of five sets A-E, as explained in previous paper [5] [6]. Where as in Set A and B are normal subjects and Set C, D and E are epileptic subjects. In this paper classification is based on MLP classifier. A MLP based classifier is used to decompose the EEG signal, the features are calculated for each sub-band. Total 10 features are considered for the classification these are entropy and variance of all the sub-bands of EEG [5]. MLP is designed with 10 input nodes, 5 output nodes and one hidden layers. We chose training function in all the layers as tansig. Further we chose 70% of the subjects for training, 15% for testing and 15% for validation. Since this is a five-class classification, the target values are determined [1 0 0 0 0] for eyes open normal subjects, [0 1 0 0 0] for eyes closed normal subjects, [0 0 1 0 0] for hippocampal subjects, [0 0 0 1 0] for epileptogenic subjects and [0 0 0 0 1] for seizure subjects. The topology chosen is Feedforward back propagation neural network.nnstart pattern recognition tool from MATLAB has been utilized for this task [9]. We have 100 normal subjects and 150 epileptic subjects. In normal subjects there is 50 eyes open subjects and 50 eyes closed subjects. In epileptic there are 50 hippocampal subjects, 50 epileptogenic zone subjects and 50 seizure subjects. Though for two-class classification seven neurons in hidden layers gives best result [5] [6]. For five-class classification, we have to increase this number to twenty to obtain accuracy 88.7% which is reasonable.

RESULTS

A three layered feedforward back propagation MLP hasbeen used for classification as shown in figure 3.

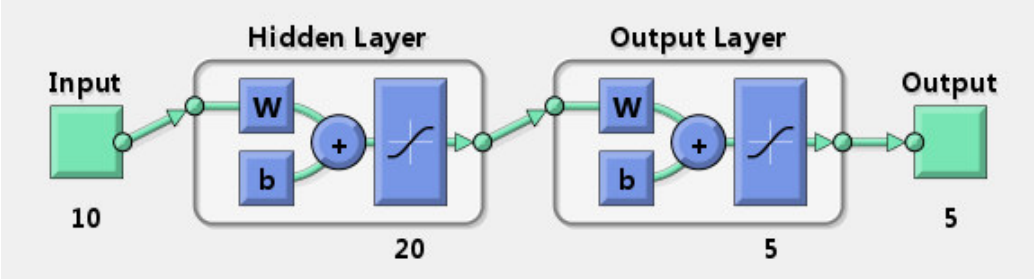

Figure 3: Multi-layer model for classification

The results in the form of confusion matrix are shown in figure 4.

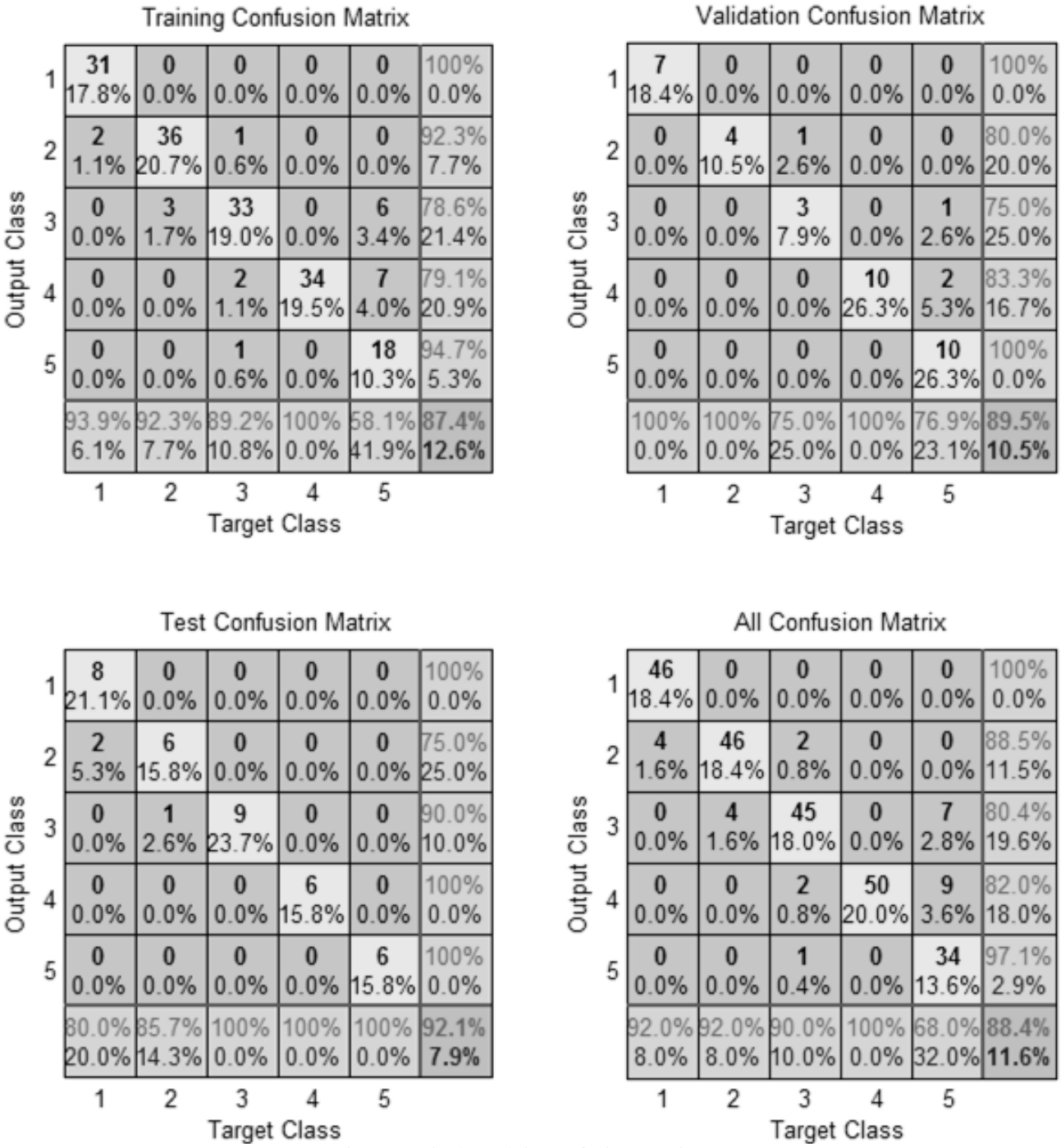

Figure 4: Final result in confusion matrix

The MLP shows the accuracy of 88.4%. In previous work with two-class classifier shows high accuracy, it is time consuming, so we use multi-class classifier.

CONCLUSION AND SCOPE FOR FUTURE WORK

Classification of epilepsy can be done in two ways. One approach is to repeatedly use two-class classifier and the other is to use one multi-class classifier. It is observed that the repeated use of two-class classifier give better

accuracy i.e. in the range of 98.7% - 100%, but is obviously time consuming. On the other hand single multi-class classifier gives lower but reasonably good accuracy (88.4%). The work may be refined further to improve this level of accuracy.

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